NemoSens®

Key features

- **Micro-AUV (Less than 90 cm length)**
- **Easy to deploy, recover and maintain**
- **Acoustic communication Modem**
- **Open architecture LINUX**
- **Programmable mission**
- **Battery life greater than 10 hours**
- **Down to 300 m operating depth**
- **Speed up to 8 knots**
- **Multi-parameter sensors**

Option

- **Conductivity Temperature Depth (CTD)**
- **Echosounder**
- **HD Optical Camera**
- **Side Scan Sonar**
- **DVL**
- **Magnetometer**
- **Sparse-LBL**

Fields of application

- **Seabed imagery**
- **Environmental monitoring**
- **Acoustic monitoring**
- **Rapid Environment Assessment (REA)**

Description

NemoSens is a compact autonomous underwater vehicle (AUV) designed for scientific, industrial and defense applications.
Lightweight and affordable, its open LINUX architecture allows users to develop their own navigation algorithm for greater flexibility and maximal use. Mission coverage can be extended thanks to swarm technology and possibility to deploy multiples AUVs.

NemoSens is also compatible with all RTSYS products range such as SonaDive diverheld systems or beacons.

NemoSens integrates the latest upgrades of both hardware and software developments from RTSYS range of products. It is therefore the most valuable and most performing micro AUV of its generation. Software functions and measurement sensors (within a 2 kg limit) can be added on demand, so get ready to extend your range.

Characteristics

◦ Length	: 895 mm*
◦ Weight	: 8.5 kg*
◦ Hull Diameter	: 124 mm
◦ Mast's height	: 60 mm

*Without payload

TABLE OF CONTENT

NemoSens® is a portable AUV, small, light and easy to deploy. It embeds numerous native functionalities such as acoustic communication, bathymetry and imaging. Navigation, communication and location are fulfilled by embedded algorithms. Its hardware and software interfaces allow adapting new software features and additional payloads for further measurement.

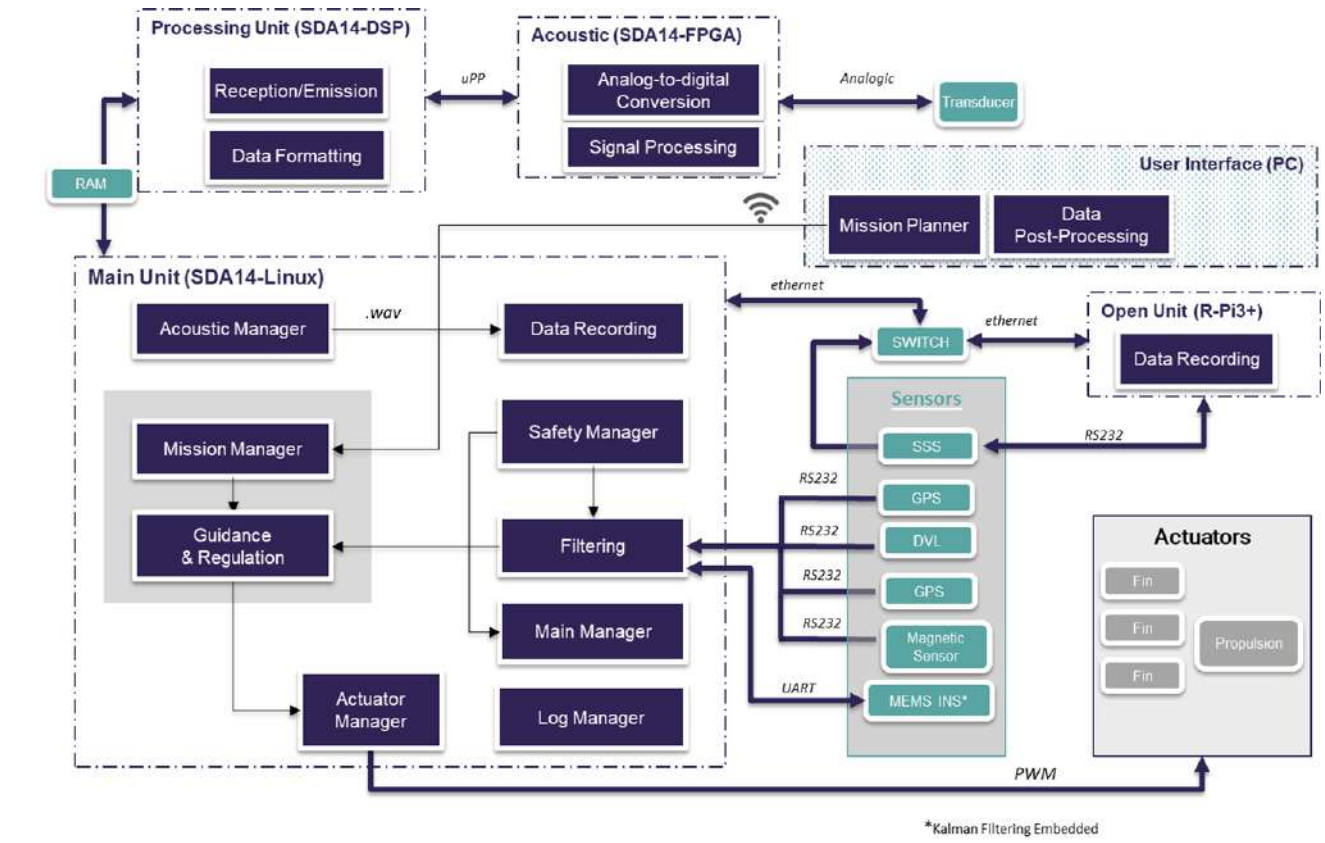
NemoSens® can be used by anyone looking for a low-cost solution for marine activities.

NemoSens® is intended to be cost-effective operational AUV with real-time positioning and acoustic communication. Its allows many applications designed to meet the current needs of marine research and industry:

- Seabed imagery;
- Environmental monitoring;
- Acoustic monitoring;
- Rapid Environment Assessment (REA).

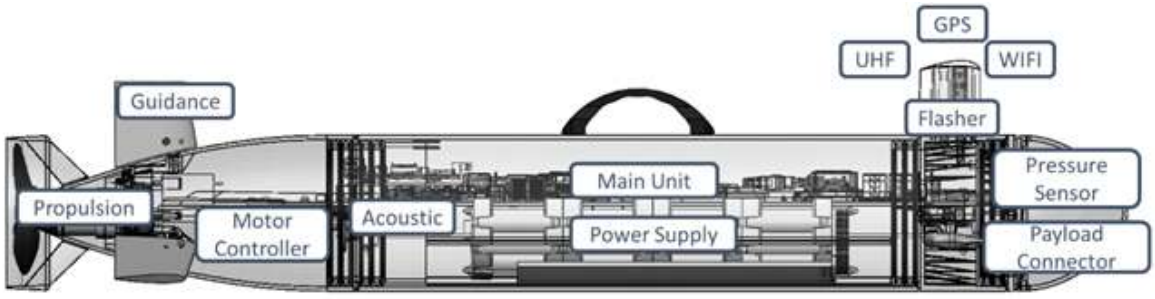
2 Vehicle Presentation

2-1 Functional description

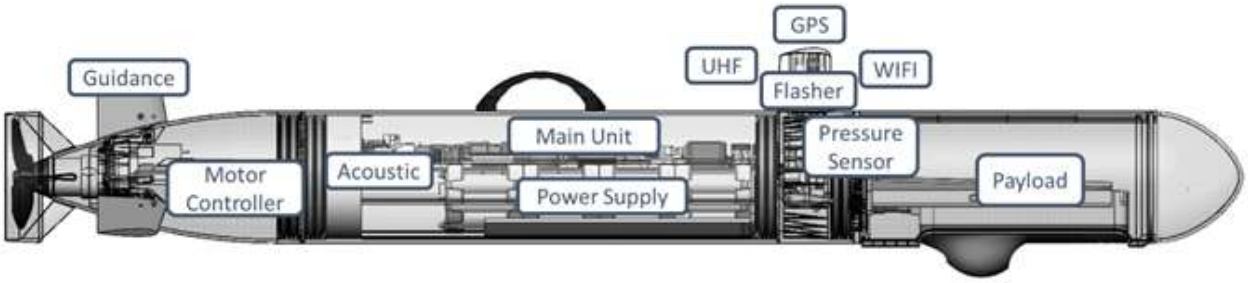


NemoSens® embeds a large range of payloads and functions to provide an appropriate solution to customer needs. The heart of the system comprises a linux-platform on which run the middleware and the strategic algorithms. Aside signal processing and acoustic management are handled by a DSP and an additional FPGA. Those processors are all part of a RTSYS acoustic platform known as SDA14 (see chapter RTSYS powered by SDA14 for further explanation).

Several combinations have already been developed using either altimeter or acoustic repositioning for a good localization, C.T.D sensor for ocean study combined with RTSYS acoustic communication.



Here is presented the example of the RBR Legato C.T.D. probe integration. A nose extension, perfectly adjusted for the probe, can be adapted on NemoSens



2-2 Mechanical description

NemoSens® is composed of 3 parts: a front section, the battery compartment and a back section.

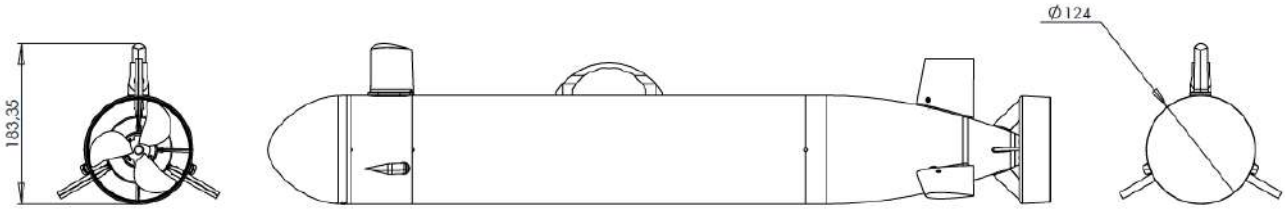
- The front section breaks down as follow:
  - A removable nose cone;
  - A multifunction mast integrating GPS antenna (1575 MHz), WIFI antenna (2.4 GHz) and UHF antenna (868 MHz), status LEDs and flashing LED for location;
  - A magnetic switch on/off button;
  - A pressure sensor (not visible);
  - A pressurization interface (not visible), also used as pressure relief valve;
  - A watertight 8-points connector for charging;
  - A watertight 6-points connector for interfacing with an optional payload;
  - A second watertight 8-points connector for interfacing with a second payload;

- The battery compartment contains the Li-ion battery (certificated IATA) and its Battery Management System (BMS) such as:
  - A battery PSM (temperature, power, amperage, short-circuit and over/under voltage detection);
  - An AUV balancing system;
  - A transducer ring (20-30 kHz);
  - The power electronics connected to the transducer;
  - The main electronic board (system management, alimentation management, interface with the navigation sensors (attitude unit, GPS, pressure), acoustic communication management).

- The back section contains:
  - The propulsion and steering;
  - Controller motor electronic board,

Characteristics:

NemoSens® Dimensions					
Model	***Length***	***Hull Diameter***	***Height of mast***	***Weight***	***Buoyancy***
NemoSens®	895 mm	124 mm	60 mm	8.5 kg	Slightly Positive



NemoSens® can navigate by either cold or warm temperature. Once in use, the AUV internal temperature shall not be impacted and battery life is the same. Storage conditions (especially temperature) might impact the autonomy of the robot. Storage advices are given to minimize the impact. AUV is usually prepared for Atlantic Ocean salinity but can be balanced on demand, according to the density of the water in which NemoSens® will be used. The use of NemoSens® in any other location shall be initiated by a weight balancing procedure.

Product environmental characteristics		
Characteristics	***Data***	
	Min	**Max**
Seawater temperature	- 5°C	40°C
Air temperature	- 20°C	60°C
Salinity	0 PSU	39 PSU
Storage temperature	- 20°C	60°C
Acceptable vibration threshold	AECTP 400 - 3,3 h	

If NemoSens® shall be used in fresh water, mechanical modifications will be applied.

2-3 RTSYS Powered by SDA14

NemoSens® acoustic and electronics mainly relies on a SDA14 card. SDA14 is based on RTSYS patent, it is an OEM platform dedicated to underwater acoustic applications. It allows acquiring analogic large-band signals (> 1 MHz) with an extended dynamic (90 dB). Direct connection to transducer is possible thanks to its great reception sensitivity.

It also integrates a linear amplifier allowing the emission of various waveforms. The RX/TX real-time sunchronization is ensured by an embedded DSP. The DSP also manages signal processing such as pulse compression or correlation including floating value management.

An embedded system software Linux runs on an ARM processor. It is the main processor of the board and allows the management, configuration and software upload. The full system does not consume more than 4 Watts when active and less than 1 mW in deep-sleep. It is a key asset for vehicle autonomy. Thanks to its small size, it perfectly fits NemoSens® diameter 140 x 65 x 30 mm.

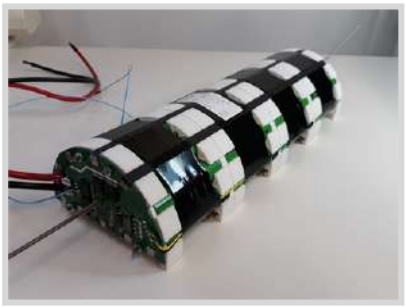
SDA14 characteristics	
Characteristics	***Data***
Reception Channel	Configurable (up to 4)
Reception Sampling Frequency	2.5 MS/s, 1.25 MS/s, 625 kS/s, 312.5 kS/s, 156.25 kS/s, 78.125 kS/s, 39.0625 kS/s
Reception Resolution (effective)	18 bits @625 kS/s
Emission Channel	1
Emission Sampling Frequency	10 MS/s
Emission Resolution (effective)	12 bits

2-4 Underwater acoustic communication

The acoustic transducer of the NemoSens® is used as an embedded modem with a 20 to 25 kHz bandwidth and an acoustic communication range up to 1.5 km. RTsys communication protocol RACAM is integrated in NemoSens® allowing underwater acoustic communication with external systems (including others NemoSens® and all products of RTsys range).

Underwater Acoustic Communication	
Characteristics	***Value***
Resonant Frequency	25 kHz (Nominal)
Useful Frequency Band	20 kHz to 25 kHz
Transmission Rate	100 bds to 5 kbds
Transmitter sensitivity	135 dB re 1uPa/V at 1 m (Nominal)
Instantaneous Power	160 dB re 1µPa
Receive Sensitivity	- 192 dB re 1µPa/V (Nominal)
Modulation	OFDM
Format	Digital with error correction

2-5 Power Management



Battery module

NemoSens® comprises a 4S battery pack delivering 600 Wh. The battery pack integrates a PSM in charge of the pack monitoring and safety management. It balances cells voltage and protects them both during charge and discharge cycles. The battery pack over-temperature protection is also completed by the PSM of each module. NemoSens® is delivered with a 1010-230 VAC 50-60 Hz battery charger. The complete charge cycle of a 600 Wh pack can take up to 7h.

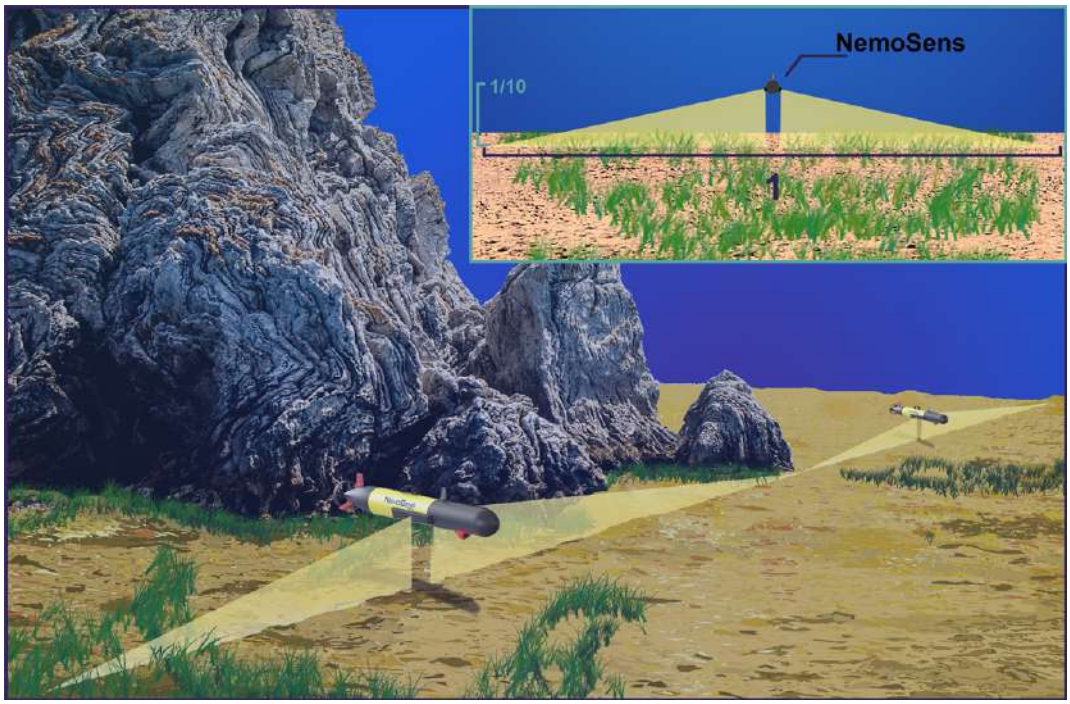
PSM protection characteristics	
Overcurrent in charge	10 A
Overcurrent in discharge	50 A
HW detection short-circuit	70 A for 5 s
Overvoltage per element	4250 mV
Undervoltage per element	2500 mV
Overvoltage of a 4S12P module	17 000 mV
Undervoltage of a 4S12P module	10 000 mV
Temperature protection	60°C

2-6 Side Scan Sonar

Side Scan Sonar (SSS) is an echo- sound technology sending acoustic pulses in water and recording echoes. The seabed and the other objects reflect some of the sound energy back in the direction of the sonar (known as backscatter), and the travel time of the returned pulse is recorded together with its intensity. It allows to display and record an accurate and continuous image of the seafloor.

SSS Characteristics

Side Scan Specifications		
Characteristics		***Data***
Frequency		450 kHz
Pulse Length		400 µs typical
Beam Width	Horizontal	0.5° nominal (@ - 3dB signal level)
	Vertical	60° nominal (@ - 3dB signal level)
Range		1m to 100m per channel
Side Scan Data Output		XTF



3 Technical characteristics

3-1 Operating limits

Operating Limits	
Characteristics	***Value***
Operating temperature (water)	-5° to 40°C
Storage temperature	- 18 to 54°C
Maximal depth - Coverage	300 m depth
Sea conditions	Sea state 4

3-2 Battery life

NemoSens®, at maximum speed can last at least: 60 minutes without payload. At minimum speed, 2 knots, the AUV can last at least 10 hours.
NemoSens can be loaded by a charger working on 110/120 V single-phase, not exceeding 7 hours of loading.

3-3 Navigation

Characteristics INS			
	Compass	***Accelerometer***	***Gyroscope***
Accuracy	Heading 1° RMS	Roll/Pitch 0.2° RMS	-
Measurement Range	± 8°	± 8 g	± 450 °/s
Random walk / Noise Density	200 µg/√ Hz	100 µg/√ Hz 150 µg/√ Hz	0.18 °/√h
Bias in-run Instability	-	20 µg	8 °/h

Pressure Sensor Characteristics	
Characteristics	***Pressure Sensor***
Pressure Range	0 - 30 bar
Accuracy	2 mbar RMS

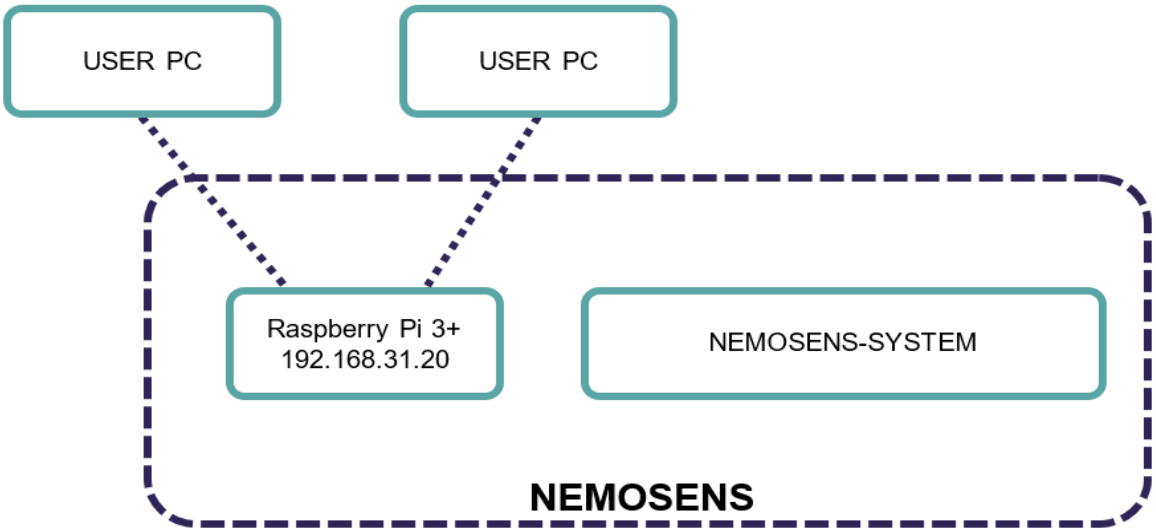
GPS Characteristics	
Characteristics	***Localization GPS***
Accuracy	2.5 m CEP
Cold Start Acquisition	26 s
Aided Cold Start	2 s
Reacquisition Sensitivity	- 160 dBm
Number of Channels	72

3-4 Data capacity and storage

NemoSens® uses a 128 GB SDA14, providing a 119 GB data capacity storage once the programming is done. On top of that, the open architecture system provides additional 16 GB storage with microSD card. Storage capacity can be increased on request.

3-5 Connection to NemoSens®

To be connected to NemoSens, the user have to be connected to the Wi-Fi network "NEMOSENS_XXXXXXX" where "XXXXXXX" is the seriel number of the product. Multiple NemoSens can be powered at the same time without bother others Wi-Fi networks.



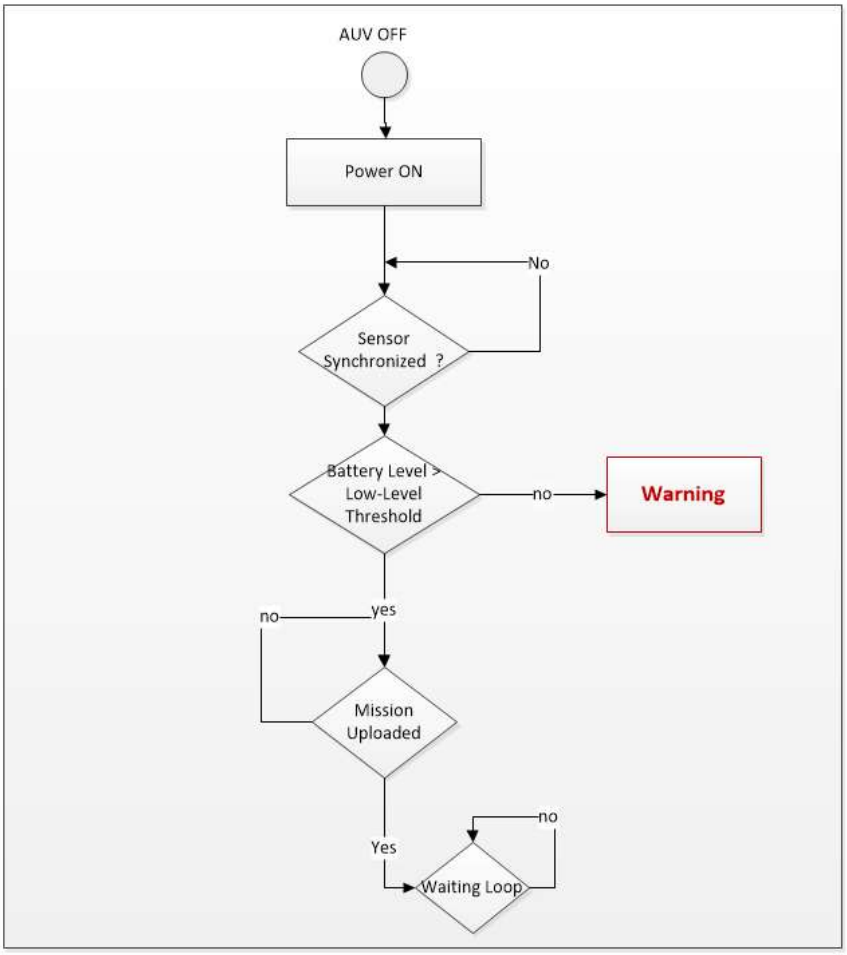
When the user is connected to the Wi-Fi network, he automatically get an IP address which allows him to connect himself to the Raspberry-Pi3+ through SSh address 192.168.31.20 (with the username "pi" and the password "raspberry").

It also allows the user to connect the graphic interface Cousto to the AUV in order to manage it.

4 On-site operation

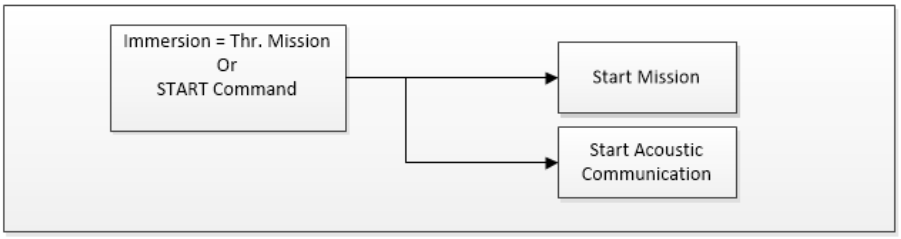
4-1 Launching

A magnet is used to start NemoSens®. It then proceeds with the initialization of the different sub-systems including localization. This operation can take up to 10 minutes depending on the GPS coverage. A RTSYS-designed-GUI is used to describe the mission and download it into the robot.



Once launched, the AUV carries out its mission in total autonomy. Starting the mission can be triggered by different means:

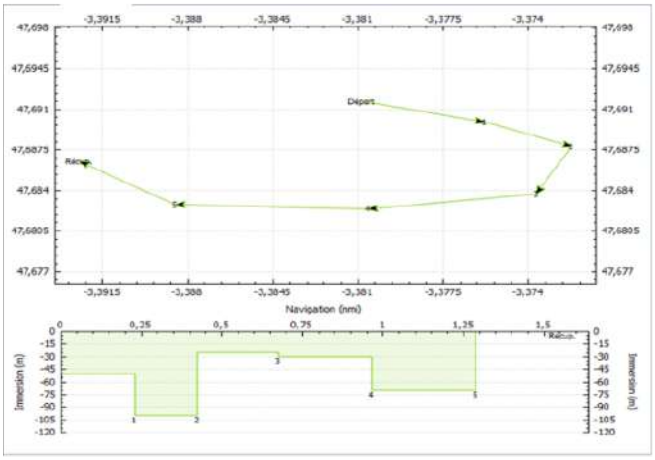
- Acoustic command;
- Immersion threshold;
- Radio command.



4-2 Mission Description

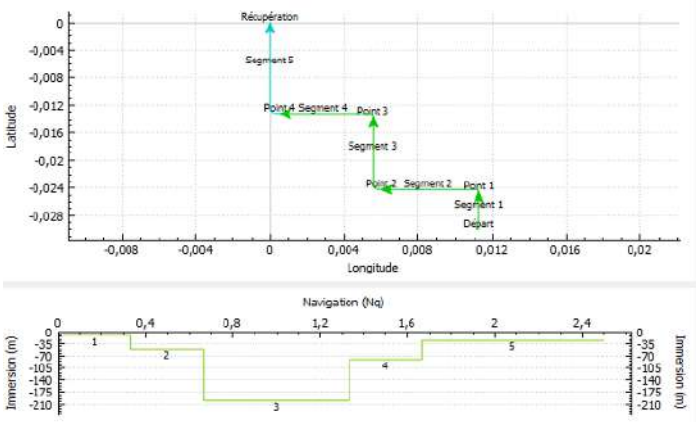
The route of the AUV can be described using the following modes:

- Waypoints navigation mode:
  - The coordinates of a launching point, a recovery point and transition waypoints are entered with the speed and depth. The AUV progresses from one position to the next. When the navigation system indicates that the AUV enters the sphere of acceptance of a waypoint, it goes on to the next waypoint;



Waypoint navigation mode

- Segment navigation mode:
  - For each segment, the heading, duration, speed, depth and recovery point are entered;
  - The new segment starts when the duration of the previous one is over.



Segment navigation mode

- Rail navigation mode:

  - The rail begins with the last waypoint and the rail ends with the coordinates of the next waypoint. The AUV follows the line between these two waypoints. The AUV can also follow an altitude (only available with altimeter) from the bottom instead of the depth;
  - When the navigation system indicates that the AUV enters the sphere of acceptance of a waypoint, it goes to the next navigation element.

Product navigation programming characteristics						
	Course (1° step)	*Speed (1 kt step)*	*Depth (1 m step)*	*Duration (1 s step)*	*Bottom (1 m step)*	*Maximum number of:*
Segment	✓	✓	✓	✓	✓	Unlimited
Waypoint		✓	✓		✓	Unlimited

4-3 Dynamic performance

Product dynamic performance	
Characteristics	*Data*
Speed	2 to 8 knots
Speed accuracy	± 0.5 knot
Heading change rate	+/- 18°/s @ 3 knots
Heading accuracy	± 2°
Depth	0 to 300 m
Minimum depth from the seabed	5 m
Depth accuracy	± 0.5 m

4-4 Safety management

For safety purpose, NemoSens® analyses in real-time several indicators and sensors data such as temperature, internal depression, voltage presence, power consumption and function status. A monitoring software treats these data and reacts accordingly to the level of alert. The three levels are described in the following table:

Safety management alerts		
Alert	*Causes*	*Action taken*
Warning	Single anomaly	A warning alert is generated and recorded. No other action is taken.
Error	Warning alert X has been raised too many time (configurable threshold for each alert), or Detection of system dysfunction (faulty status or incorrect data).	No Error alert is generated. The mission is aborted, the AUV gets into Rescue Mode.
Default	The watchdog signal of the monitoring software ceases to function or is altered	A default alert is generated. The mission is aborted, the AUV gets into Rescue Mode.

The alerts, whatever their safety level, are recorded by the system and logged. A single anomaly can then be analyzed by the user in post-treatment.

In addition, the main unit is protected by a watchdog preventing the AUV to remain locked. In case of watchdog intervention, NemoSens® directly gets into Rescue Mode.

4-5 Recovery function

At the end of its mission, the AUV surfaces and updates its GPS coordinates. It then rallies the pre-programmed recovery location (if option enable). To help its localization, the NemoSens® is equipped with the following devices:

- A LED strobe located in the front section on its mast;
- A GEOSYS (868 MHz - UHF Tracker);
- A Pinger activated at the end of the mission or in Rescue mode (see table below).

Localization modes		
Localization mode	***Devices in operation***	***Triggering factor***
Signaling	LED strobe, GEOSYS and Pinger The AUV is powered and the propulsion activated	Entered when in rally phase and GPS data are acquired
Recovery	LED strobe, GEOSYS and PINGER The AUV propulsion off.	Entered when the AUV reaches the recovery position
Rescue	LED strobe, GEOSYS and Pinger on back-up battery. Other sub-systems are all turned off.	Entered either when the main battery fails and the AUV is in recovery or when in Error or Default alert.

GPS tracker by UHF function

GEOSYS system is portable and easy to use, allowing AUV's localization.
NemoSens® is equipped with an 868 MHZ UHF transmitter that transmits its GPS position. When the AUV is on surface the position is received by the hand-held GEOSYS receiver that displays NemoSens® on its screen, as well as distance and true bearing to the target.

1. UHF Receiver antenna
2. ON / OFF button
3. OLED screen
4. GPS antenna
5. Two AA batteries

Flasher function

GPS mast is equipped with a flasher.

NemoSens® recovery characteristics	
Characteristics	***Data***
Time before reaching recovery point (if option enable)	15 minutes
Accuracy of the GPS surfacing point	10 meters
GEOSYS maximum detection from a RHIB	2 kilometers
GEOSYS maximum detection from a surface ship (bridge)	8 kilometers
Accuracy of the AUV reaching its recovery point (if option enable)	< 100 meters

5 Open-Architecture

5-1 Electronic Interface

NemoSens® allows the user to connect up to two payloads. A first 6-pts SubConn connector is used and offers an interface for sensors using either RS232, RS485 Ethernet, USB or CAN. The second connector is a 8-pts SubConn. NemoSens® provides [5-24]V on each connector with a maximum of 2A. Both payload shall be supplied with the same power level.

Front Interface

An open-hardware Raspberry R-Pi3+ is connected to the payload(s). Through the interface, the user can configure the pin out of the connectors and set the interface as chosen.

5-2 Software interface

NemoSens® has been built with two independent systems. NEMOSENS-SYSTEM based on the OEM RTSYS SDA14 is in charge of the navigation and the AUV safety. Acoustic communication, mission management and regulation are also implemented on this main system.

By default, NemoSens® is delivered with communication and navigation capabilities. The user has the option to modify the navigation interacting with this main system thanks to common-used middleware such as MOOS-IvP or ROS.

It is recommended to run only one of those two middleware at a time on the R-Pi3+. RTSYS provides a buildroot for the R-Pi3+ enhancing the development by providing customized cross-compilation tools.

NemoSens® as an open-hardware µAUV allows the customer to develop its own software to interface with additional payload or to test navigation algorithms. The architecture is thought in such a way that additional software added by the customer cannot hack the standard system.

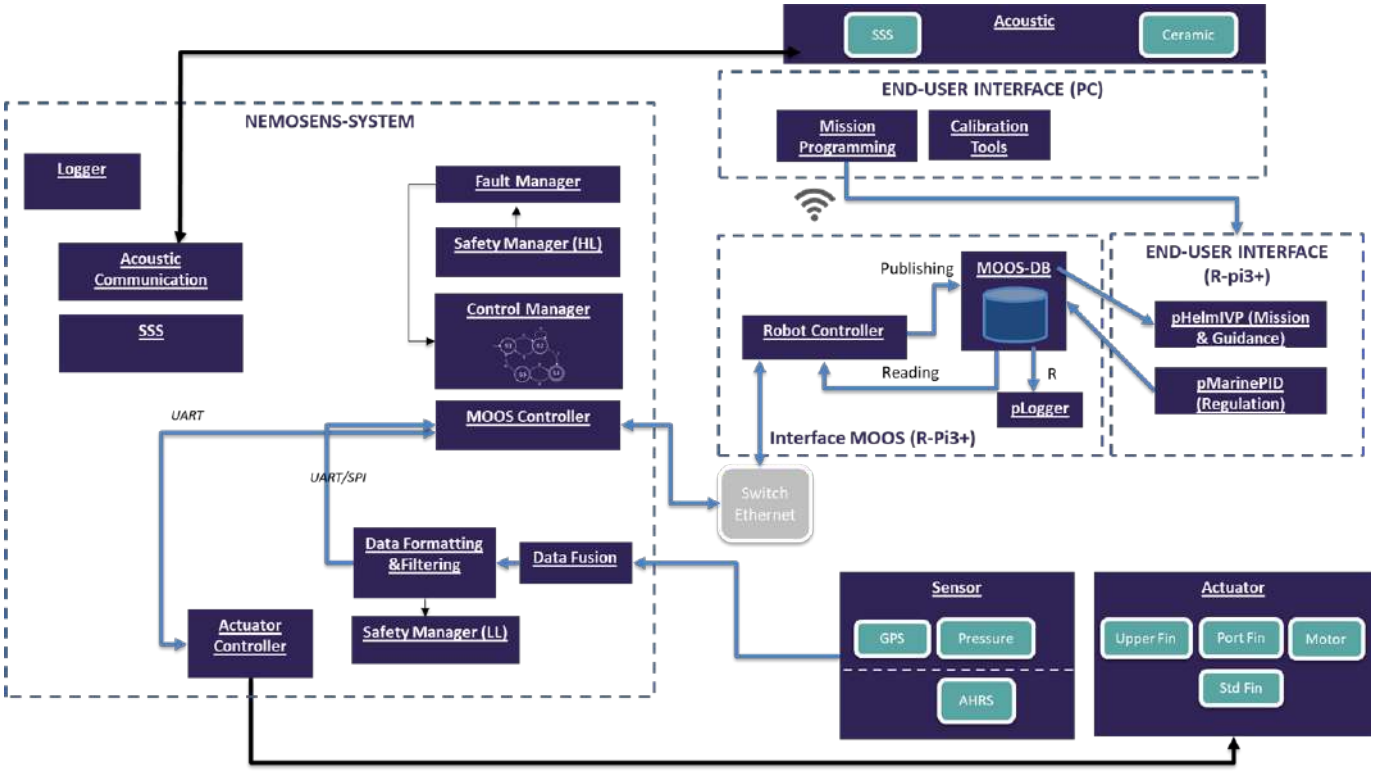
The independency of the systems guarantees the safe behaviour of the µAUV in case of overcharge of the CPU or crash of the user applications ; NEMOSENS-SYSTEM will handle it.

Middleware

MOOS-IVP Interface

MOOS-IvP is a set of open source C++ modules for providing autonomy on robotic platforms, in particular autonomous marine vehicles.

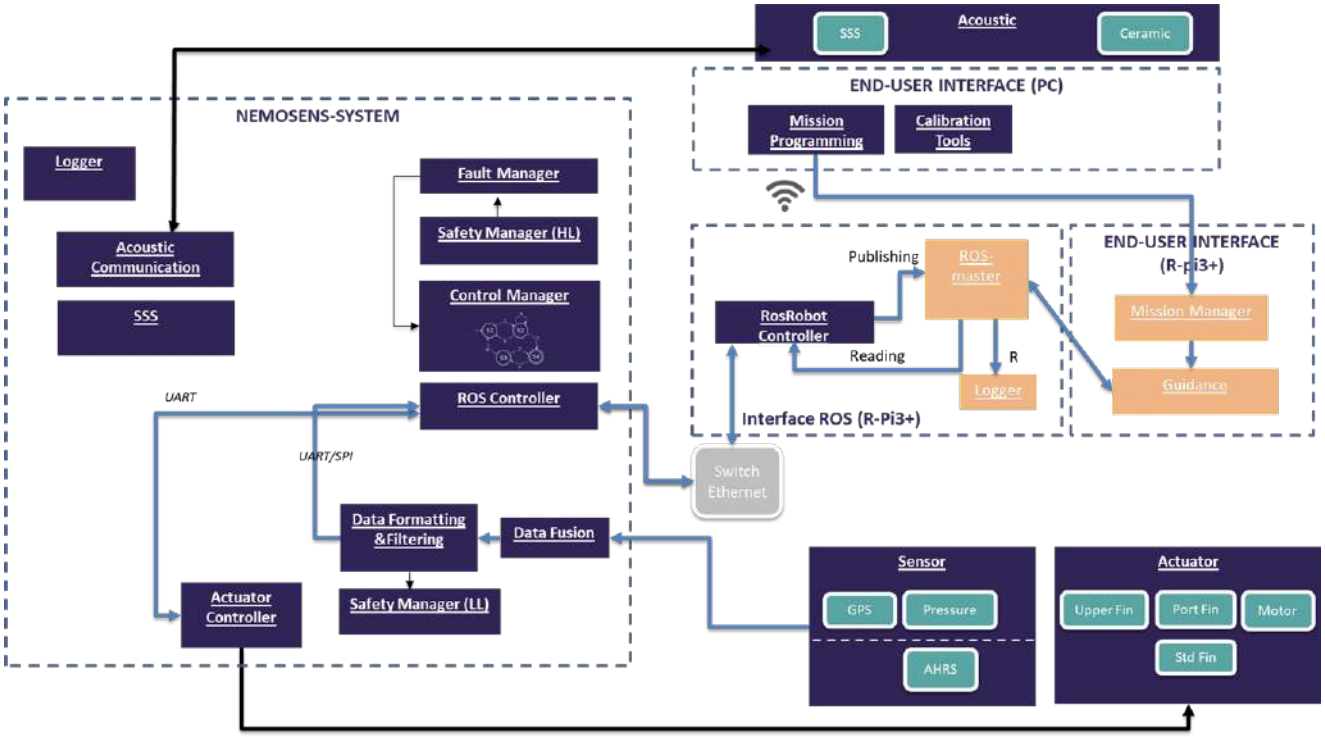
NemoSens® architecture is as followed:



MOOS can be described as autonomy middleware which implies that it is a kind of glue that connects a collection of applications where the real work happens. MOOS does indeed connect a collection of applications, of which the IvP Helm is one. MOOS is cross platform stand-alone and dependency free. It needs no other third-party libraries. Each application inherits a generic MOOS interface whose implementation provides a powerful, easy-to-use means of communicating with other applications and controlling the relative frequency at which the application executes its primary set of functions.
NemoSens® is delivered with example using this architecture. The key notion is the communication between distinct processes thanks to a publish-subscribe database called the MOOSDB (Mission Oriented Operating Suite - Database).

ROS Interface

The Robot Operating System (ROS) is a set of software libraries and tools that help build robot applications. It is an open source interface, which provides developer tools from drivers to state-of-the-art algorithms.



ROS offers a message passing interface that provides inter- process communication and is commonly referred to as a middleware. It provides:

- Publish/subscribe anonymous message passing;
- Recording and playback of messages;
- Request/response remote procedure calls;
- Distributed parameter system.

NemoSens® is delivered with example using this architecture.

Navigation & Control

NemoSens® opens the control interface to allow the user to develop and test his own control/regulation according to his needs. Three levels of control are available.

Standard Control

The user does not require to develop its own control/regulation and use the default one of NemoSens®. A mission will be programmed using the mission programming tool and NemoSens® will navigate using RTSYS control/regulation for this mission. NemoSens® can navigate following those commands:

- Segment (given bearing);
- Waypoint (navigate to a known position (coordinates));
- Rail (follow a line between two waypoints);
- Circle (navigation in circle around a given position (coordinates));
- Surface (static on surface).

Those commands are given with additional information such as speed setpoint, immersion, duration and altitude (optional).

Navigation Setpoint Customization

The user can modify high-level control and can access to NemoSens® state data:

- Latitude;
- Longitude;
- Immersion;
- Speed;
- Pitch;
- Yaw;
- Roll;
- Altitude (optional).

Then, the user can compute the setpoint for the following:

- Pitch;
- Speed;
- Immersion;
- Altitude (optional).

Nemosens® navigation system on NEMOSENS-SYSTEM will retrieve the setpoints and compute the command to be applied on fins and propulsion accordingly.

Fins and propulsion command

The user can fully control NemoSens® control/regulation, he will access to NemoSens® state data:

- Latitude;
- Longitude;
- Immersion;
- Pitch;
- Yaw;
- Roll;
- Altitude (optional).

Then, the user will compute his own commands to be applied on actuators base on his own regulation:

- Fins angles (top, port, starboard, speed);
- Propulsion.

Nemosens® navigation system on NEMOSENS-SYSTEM will retrieve the commands and applied them directly on actuators.

Safety control

Despite providing a wide range of autonomy to the user, NemoSens® integrates safety modules to prevent the µAUV to exceed physical limits and control thresholds. Several safely levels are available.
The physical limits of the system are given by the constructor and cannot be modified by the user. The control thresholds depend on the navigation algorithm. Default parameters are given when using native guidance and regulation, the user shall have access to modify those values. Finally, the user shall configure additional thresholds in accordance with its use case and its environment.

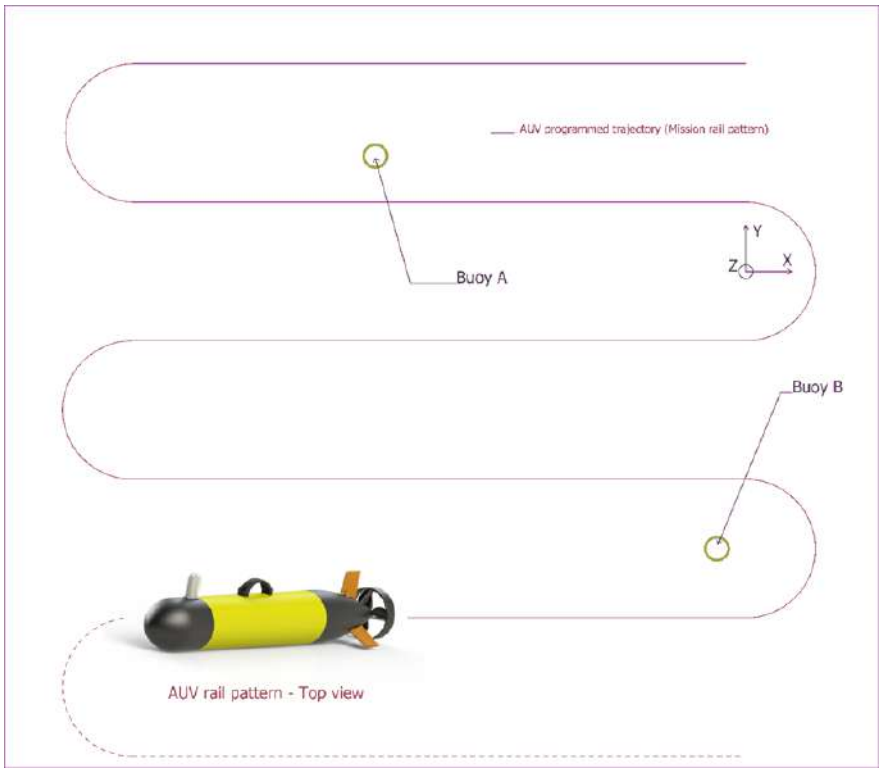
6 Features

6-1 LBL positioning system

NemoSens® can be equipped with a Long Baseline (LBL) acoustic positioning system. This system determines the position of NemoSens® by acoustically measuring the distance between its position and the n Baseline transponders deployed. The position of the Baseline transponders being known, a high level of accuracy is obtained in the positioning.
Each surface represents a node of the deployed acoustic network. The amount of nodes will determinate the level of navigation accuracy.

Acoustic communication is standard on NemoSens® and additional algorithms such as repositioning can be added based on the already integrated hardware. The main principle of the repositioning technology and its assets are presented below.

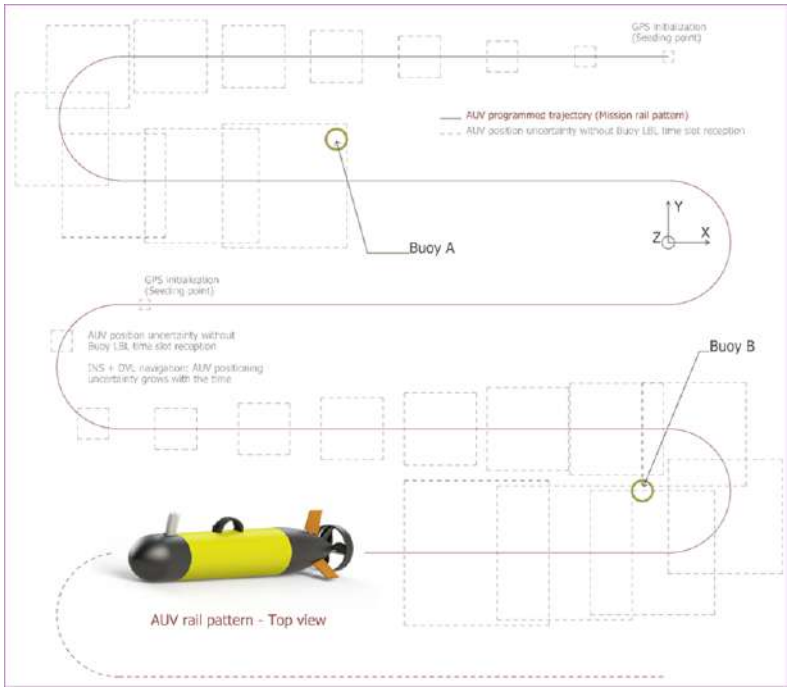
The following pattern (µAUV track in red) is an example of NemoSens® mission. Buoy A and B are positioning buoys.
Positioning accuracy is the main challenge of any underwater system. Immersion is controlled by NemoSens® depth sensor (and optional altimeter) (Z).



Top view of NemoSens® navigation

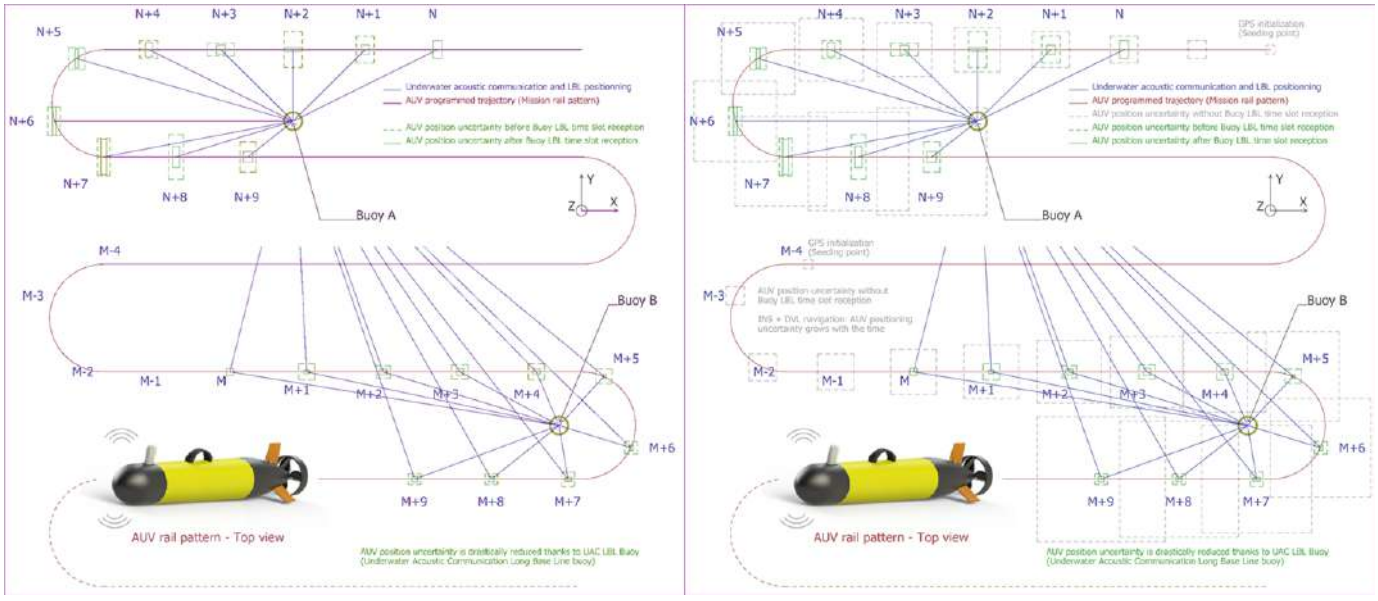
NemoSens® is equipped with positioning sensors such as GPS and INS, which have their own accuracy and lead to a µAUV drift along the mission. The uncertainty of the navigation is displayed below. Each square box (in grey dash points) represents NemoSens® uncertainty of positioning.

The box growth represents the drift of the navigation system.



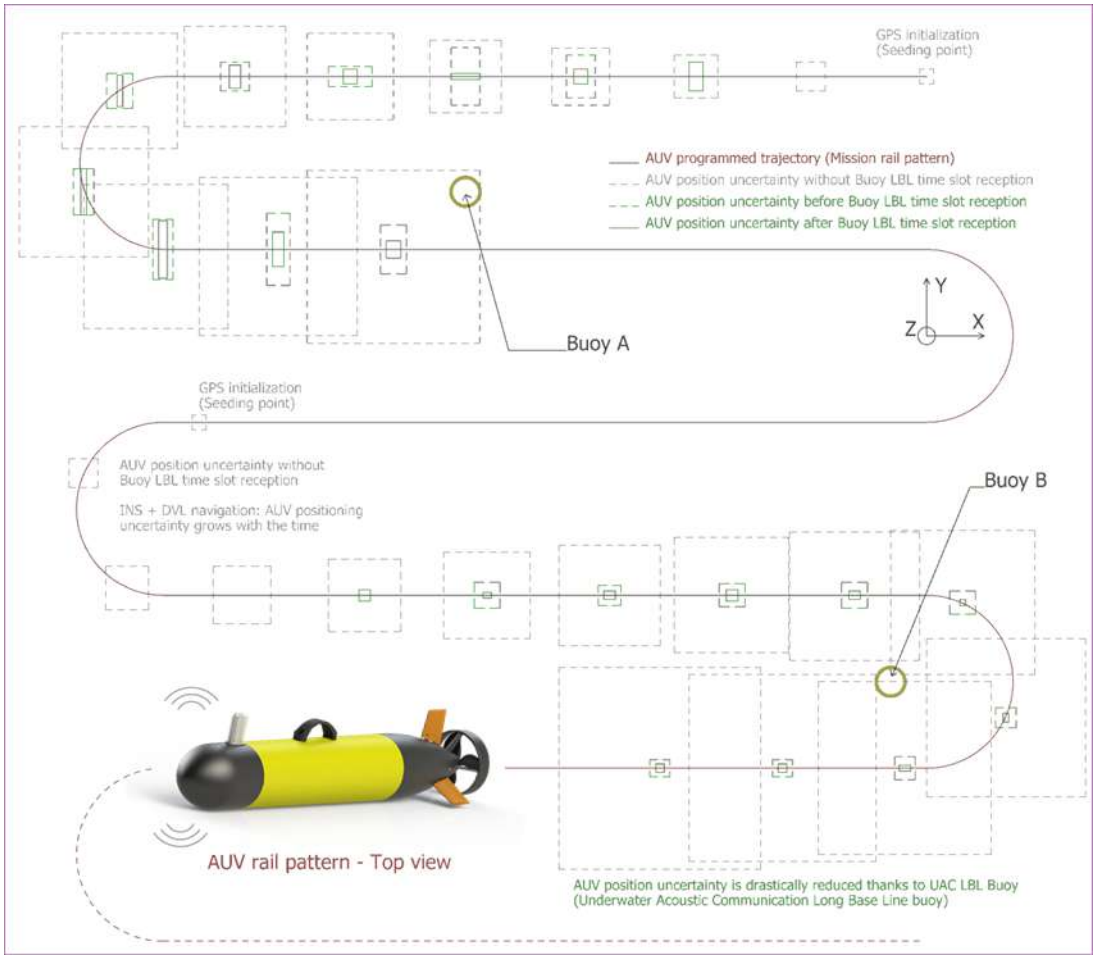
Communications between buoys and one µAUV are displayed below. Blue lines represent Underwater Acoustic Communication (UAC) frames sent periodically by the buoy according to the time slots of the TDMA.

The uncertainty of µAUV positioning is represented by the green boxes below. Boxes uncertainties are contracted by sparse-LBL. On the top of the image, NemoSens® communicates only with A buoy when it communicates with both A & B on the bottom part.



Green boxes represent the uncertainty of positioning of the AUV thanks to RACAM sparse-LBL protocol.

Finally, the image below sums up the different cases where an AUV is equipped with accurate equipment such as GPS, INS-FOG, DVL, ... (grey boxes) and NemoSens with RACAM sparse-LBL protocol (green boxes). The uncertainty of the µAUV positioning is not dependent anymore in the mission duration as the drift won't increase with time.



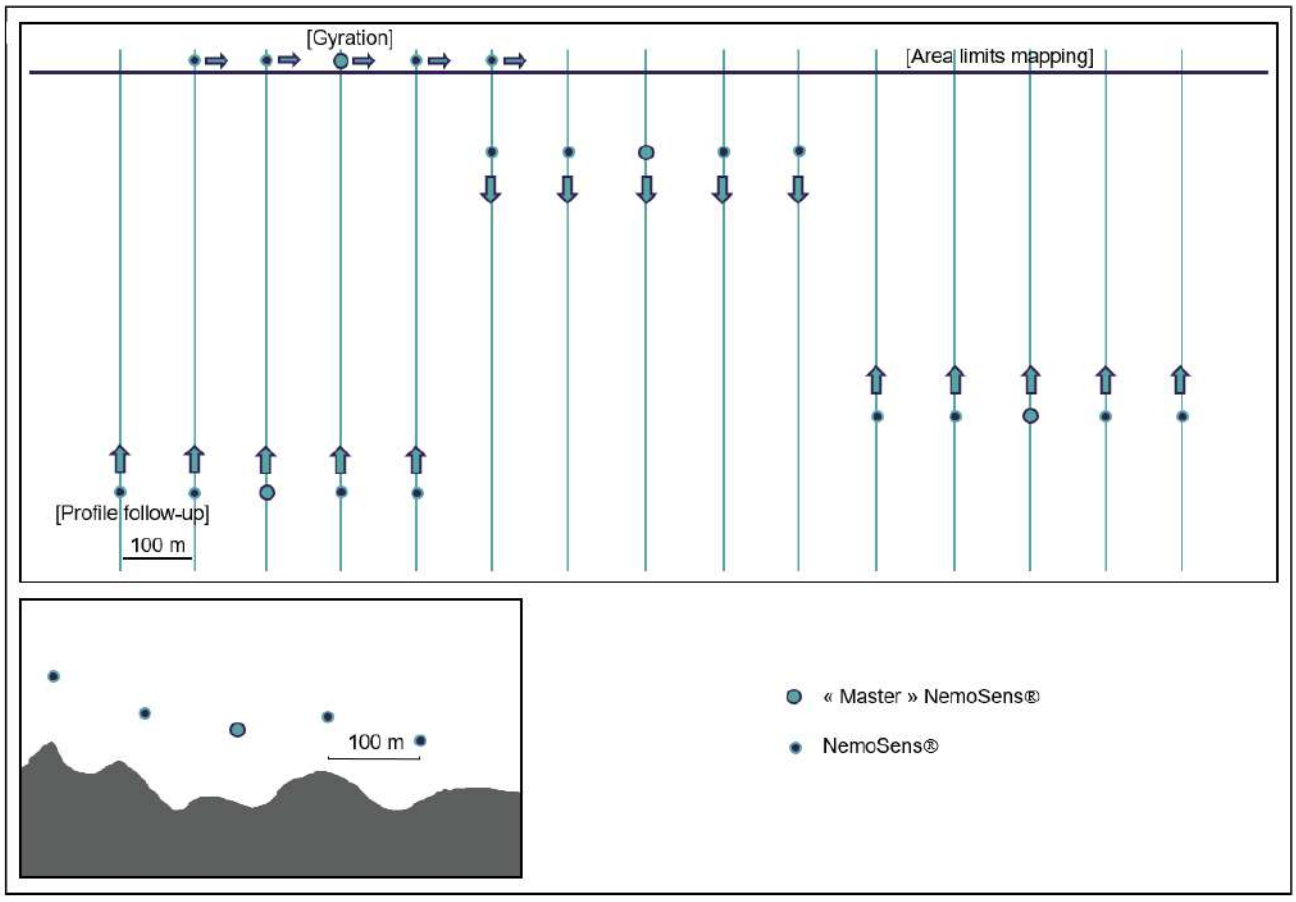
6-2 Swarm mode

The swarm mode is an important asset of NemoSens® allowing up to 10 AUVs to be able to communicate together. For instance, 8 AUVs can cover a 10-km-underwater seabed area in a homogeneous task.

Product Acoustic characteristics	
Characteristics	**Data**
Maximum pulse length of messages	1.5 s
Maximum distance between AUV	1500 m
Memory refreshing time	3 s per AUV

Master driven NemoSens® Fleet

A NemoSens® fleet can be coordinated around one "master" AUV or µAUV thanks to acoustic guidance. In that example, the swarm is spread apart the “master” robot, moving all abreast or in single file. These two coordinated motions are sufficient to surround a wide underwater seabed area.



5 NemoSens® swarm covering up an area

The fleet can cover a large area in latitude/longitude or in altitude ; indeed, it is possible to have a fleet of NemoSens® following the same past at different depths.

7 Software

The dedicated NemoSens® licensed Software allows:

- The preparation and the post-analysis of a mission
- The upload of the mission to the NemoSens®,
- The subsystem status real-time monitoring on the NemoSens®

The set-up of NemoSens® is fast and simple (less than 10 min).

8 Delivery

The delivery includes the following:

- The µAUV without payload;
- An accessory package containing the following:
  - GEOSYS (optional);
  - Spare fins;
  - 110 - 230 AC battery charger;
  - Snap rings;
  - A laptop or tablet (optional).
- The documentation: Operating manual, Maintenance manual and Safety manual;
- A complete set of development for the open-architecture unit (buildroot, interface description, example);
- A software installer (linux and windows compatible) including mission planner, system configuration and real-time µAUV follow-up.

8-1 After delivery

The tow standard levels (OLM and DLM) of integrated logistic support (ILS) are available. The terms and conditions of this support can be customized according to the user needs.

Export conditions

NemoSens® is subject to export and re-export regulations that may be imposed by applicable French laws.

Moreover, options may be subject to export restrictions and specific licenses.

An individual export license initiated by RTSYS is mandatory in case of temporary or definitive export.

In the case of a contract signature, the customer will provide to RTSYS a certificate of non-transfer and use, duly completed, stamped and signed by the parties concerned.

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